

pyrolyzed glass fiber in electrical contact with the conductor and an exterior grading layer of semiconducting material.

The Examiner further notes that it would have been obvious to form these layers with similar coefficients of thermal expansion.

Finally, the Examiner rejects certain claims over the Patent Specification 468,827 (this is a U.K. patent of a German applicant).

According to the Examiner, Elton discloses the invention except for a stator having slots with cylindrical openings, and the U.K. Specification provides such an arrangement.

The Examiner's rejection of the claims is respectfully traversed for the reasons set forth below.

Takaoka discloses a power cable and method and manufacture. However, Takaoka does not disclose the use of such a cable in a machine. There is no suggestion that the cable of Takaoka could be used in a machine in the manner claimed. Further, there is no teaching in Takaoka for confining the electric field within the cable.

While the invention employs insulated and uninsulated conductors in the conductive core of the cable, under some circumstances, uninsulated conductors may be employed alone. For example, in operations where the magnetic flux is relatively low, eddy currents, which may be produced in the conductive core, may not be sufficient to cause excessive heating. Thus, the expense of providing insulated conductors would not be necessary. In those situations where the magnetic field intensity is high, it would be useful and desirable to insulate the conductive elements so that eddy currents are suppressed. However, in any case, at least one conductor would be uninsulated and would be in electrical contact with the inner layer so as to establish an equipotential surface for confining the electric field. The arrangement of the invention thus allows for high voltage operation in electric machinery not heretofore achievable.

Elton '165 describes a high voltage cable having an inner layer of semi-conducting pyrolyzed glass fiber material and an outer layer of the same material in which the outer layer is grounded. Once the teaching of Elton is fully considered and viewed as a whole, it will be

apparent that Elton does not show or suggest the invention alone or in combination with any of the references cited. Even though it is suggested in Elton to apply a semi-conducting layer in the form of a pyrolyzed glass tape to a winding in a dynamo-electric machine, and to apply such a layer in a power cable, there is no indication that the use of such a cable would be useful in a dynamo-electric machine. Indeed, the disclosure of Elton '165 stems from a parent U.S. Patent 4,835,565 which describes three different applications for a semi-conducting layer. One application is for using a pyrolyzed glass tape in a layer in conventional winding or armature bars in a known high current, low voltage dynamo-electric machine. A second application set forth in the parent of Elton '165 is for a housing to reduce electric discharge in an enclosed circuit. Finally, the parent of Elton '165 employs a semi-conducting pyrolyzed glass layer in a conventional cable. However, there is no proposal to use the cable shown in Elton '165 in a dynamo-electric machine. It is only the semi-conducting tape that is used in a dynamo-electric machine. The arrangement of Elton does not provide a solid insulating system as described and disclosed in the present invention

It is clear that Elton describes the use of a semi-conducting layer as a grounding tape around conventional insulated electrical windings or armature bars which are disposed in the slots of a conventional machine. It should be emphasized that Elton '565 discusses the use of an insulated conductor in the winding of a dynamo-electric machine. Here, the conductor is a conventional rigid bar, not a cable. The Abstract of Elton '165 is identical to the Abstract of the parent which discloses in the specification three different and diverse applications for semi-conducting pyrolyzed glass fiber. Nowhere does the parent Elton et al. suggest that the cable described in the specification could be used for such purpose. The portion of the specification of Elton '165 noted by the Examiner discusses the conventional winding in the background but goes on to describe a high-voltage cable without suggesting that the cable could be used as the winding in the dynamo-electric machine. In view of the differences in operation between conventional armatures and windings that use pyrolyzed glass tape and a power cable that also uses pyrolyzed glass tape, one of ordinary skill in the power generation art would not have been motivated at the time the invention was made to substitute the power cable for the

winding since the prevailing thought at the time was that cable wound electric machines would not operate successfully at high voltage. Furthermore, Elton itself does not teach or suggest the substitution but merely provides yet another indication that those of ordinary skill in the power industry would recognize windings as being in a different field of endeavor than power cables. Elton merely describes that the pyrolyzed glass tape may be used in these two different fields of endeavor, namely, windings in electric machines and also in power cables. Thus, it is believed that Elton '165 has no applicability to the arrangement described in the present invention.

There is no suggestion that the conventional winding of Elton '565 having a semiconducting grounding tape could be modified by substitution of the cable of the invention. The reference simply employs semi-conductive material in conventional machine winding and in a cable structure. Elton '165 does not disclose that it would be useful to use the cable as the winding. This is because, for a given power level $P=E \cdot I$, where P =power, E =voltage, and I =current, when the voltage is high the current is consequently low and vice-versa. As such, the conductor in a high voltage machine according to the invention can be flexible and have a relatively small cross section (as in a cable). Such conductor need not have a capability of carrying a high current. In a high power machine in which current is high and the voltage is relatively low, the conductors are formed of shaped, rigid, high cross-sectional area copper bars. The problems associated with high current operation typically involve thermal considerations, whereas at high voltage, insulation breakdown is a predominant failure mode. Thus, it is not obvious to combine an essentially high voltage device, such as a power cable in a high current device, such as a high power machine. It is not merely the fact that the voltage in one machine is much higher than the other, it is that the problems associated with high voltage operation are entirely different from problems associated with high current operation, and the focus of the designer is thus entirely different.

Thus, it is not obvious to combine an essentially high voltage device. Such as a power cable in a high current device. such as a high power machine in a turbo generator plant. It is not merely the fact that the voltage in one machine is muc higher than the

other, it is that the problems associated with high voltage operation are entirely different from problems associated with high current operation. and the focus of the designer is thus entirely different.

The Examiner has indicated that it would be obvious to employ layers having similar coefficients of expansion because it is known in the art that the expansion of the two layers would be the same and would thus be desirable in order to prevent cracking of the insulation and wear between the two. The Examiner's argument, however, ignores that fact that there are many other considerations when building a winding. For example, the materials making up the winding of the present invention must have properties which not only avoids the problem of cracking and void formation. but must also provide adequate insulation and dielectric strength, semiconductivity, magnetic permeability, insulating properties and field confining properties. It is not clear that one would be able to achieve all of these various requirements merely by selecting materials with a particular matched coefficient of thermal expansions. This is especially true if the insulation properties are not adequate or if conductivity is too high or too low, which would create other problems. If all that was necessary would be to match thermal coefficients, the problem might well be routine. However, there are a great number of requirements and it is not simply a matter of choice to find the materials and properties which would achieve these requirements satisfactorily.

An example of a system which has good insulating properties, but certainly uses diverse materials is a conventional transformer, wherein the windings are formed in layers with paper insulation and spacers between the layers. The insulation provides stand-off voltage protection and the spacers allow for the flow of oil between the layers. The insulating properties of the paper and the oil are closely matched. However, it should be obvious that other physical characteristics of the paper and oil are totally different. Thus, it is believed that the combination of elements which allow for the manufacture of a high voltage machine for a synchronous compensator plant are not obvious or simply matters of routine choice.

It should be further emphasized that the discovery of a problem must be considered even if the solution appears simple. The present invention employs a high voltage cable as a winding in machine employed in a synchronous compensator plant. It is not clear that the features which make a high voltage cable useful in the distribution and transmission context would likewise be useful in a cable employed in a machine. Indeed, extra precautions have been taken in order to protect the cable from overheating while operating within a machine in according with the present invention, which precautions are not necessary in a conventional transmission or distribution line. Thus, the problems associated with the fabrication of a winding in an electric machine are different from the problems associated with the fabrication of a cable for transmission or distribution of electricity. The Applicants emphasize however that a number of critical ideas had to be combined in order to make a workable and practical system. Once the critical and non-obvious characteristics and functions were identified, then the Applicants proceeded to assemble the necessary components and material to build a workable system.

It is not self-evident that some desirable system for reinforcing the cable would be useful to prevent the formation of voids in the insulation. However, if diverse materials were introduced into the system, those materials might well have an effect on the overall performance and operability of the resulting device. The effect could be detrimental to the successful operation and commercialization of such a device.

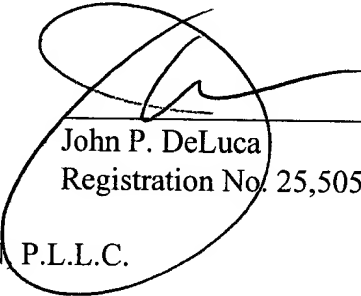
With respect to the Examiner's rejection based upon the U.K. patent, this reference merely shows similarly sized conductors a1, a2 and a3, surrounded by insulation i1, i2 and i3. The conductors a1-a3 are all the same size, whereas the insulation i1-i3 increases radially with respect to the center of the machine. Likewise, the opening in the stator increase radially. This is because the voltage in the conductors increases as the number of winding turns increases radially. The U.K. reference simply suggests increasing the insulation in order to increase the ability of the material to withstand the electric field stress. The reference does not suggest using a cable, even though the conductors are round, but simply suggests increasing the insulation to increase

the breakdown potential. However, this is not the teaching of the present invention which is designed to employ a field confining cable in order to make a practical high voltage machine. Indeed, the U.K. reference refers to the conductors as individually insulated slot conductors equal around cross-section arranged so that the conductors are located one behind the other relative to the stator axis and the insulation increases in thickness from the conductor located nearest the bore of the stator and outwards so as to be appropriate for the different potentials occurring with respect to the low potential end of the winding. The so-called high potential alternating current is not defined and a simply insulated wire would not operate as in accordance with the teachings of the present invention.

In summary, none of the references, either alone or in combination, show an arrangement which does not suffer from at least one important defect, namely: the inability to confine the electric field; unacceptable field peaks; unacceptable heat concentration, i.e., high cooling demand; excessive eddy currents; and too high or too low a resistivity of the inner and outer layers.

In view of the foregoing, it is respectfully requested the Examiner reconsider his rejection of the claims, the allowance of which is earnestly solicited.

Respectfully submitted,



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